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Wellness Routines with Wearable Activity Trackers: A Systematic Review

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WELLNESS ROUTINES WITH WEARABLE ACTIVITY TRACKERS: A SYSTEMATIC REVIEW

Completed Research

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Abstract

With the advent of technological advancements, different types of wearables are built and introduced to individuals to better quantify and monitor their lifestyles. This helps in creating awareness among individuals about their health and wellness, motivating them to make healthy changes in their lifestyles. The young-elderly (aged 60–75) age group constitutes an important segment of the society, which is growing worldwide, but with little or no attention of researchers and practitioners. Wearables offer lots of open research avenues; with a proper integration with new and existing mobile applications it will be possible to build systematic and smart life routines for users. Designing wearables for young elderly is an interesting design challenge with its own set of requirements. We have carried out a systematic review of current literature to get an understanding of how wearables can support wellness routines for individuals. The purpose is to study the current state of art in creating wellness routines with wearables as technological interventions. In doing so we present a categorization of existing approaches and a summarization of different design recommendations that serve different design goals. The review also suggests a clear lack of efforts to address the needs of the young-elderly. We suggest an introduction of action design research to encourage users to be part of a co-creation process that would help to lower adoption barriers for the young elderly.

Keywords: Wearables; Activity Trackers; Wellness; Routines; Behavioural Change

1. Introduction

Wellness of individuals plays a vital role in improving their quality of life. The modern lifestyle is often defined by lack of physical activity, junk foods and high work stress etc. that negatively effect people's wellness and in turn their quality of life. A WHO report shows cardiovascular diseases, digestive diseases and diabetes on the list of prevalent chronic diseases in Europe (Wood-Ritsatakis and Makara, 2009). These and other chronic diseases can be controlled if individuals act early in taking preventive measures and follow a healthy lifestyle. The last decade has seen considerable efforts by the policy makers along with the industry and academia to define strategies and methods that focus on prevention-driven approaches to a healthy lifestyle. Investing in prevention would improve the quality of life and well-being of people and societies (Wood-Ritsatakis and Makara, 2009).

With advancement in technology, technical interventions are increasingly being explored for their influence on individuals' routines and everyday life in order to develop healthy habits among them. Wearable activity trackers when used as technical interventions, have great potential to influence individuals' wellness in everyday life as they provide means to collect, quantify, analyse and monitor different attributes of the wearer and her environment. They can help in providing personalized wellness services to wearers. According to IHS (Wea, 2016), the wearable technology market is drastically increasing. In the year 2012 wearable technology revenue was approximately 8.5 billion dollars with 96 million devices. By the

year 2019 the revenue is expected to be 32 billion dollars with more than 230 million devices (Wea, 2016).

Researchers, in collaboration with industry, are discovering novel ways to use wearables to encourage behaviour changes among individuals and for building healthy routines. Routines are regular activities that are part of a person's daily life. Developing wellness routines and making behavioural changes for users to create healthy lifestyles have been an active area of research e.g. (Greaney et al., 2004), (Phillips et al., 2004), (Patel and O'Kane, 2015), (Gouveia et al., 2015a). Different types of technical and non-technical interventions are used to create changes in routines producing different types of changes in daily routines of individuals. However, in order to support daily activities of its users, wellness services need to address human diversity (Duval and Hashizume, 2006). The needs of individuals vary with gender, age-group and other different characteristics.

We conducted a systematic literature review to study the use of wearable activity trackers as behavioural interventions to improve wellness of individuals. This review helps us in understanding how wearables are currently being used to develop wellness routines in individuals and investigate any research gaps in this domain. In doing this, we clearly distinguish between digital healthcare services (DHS) and digital wellness services (DWS). Digital wellness is part of digital healthcare; however, they both have their own set of design requirements. Digital healthcare services are focused on diagnosing health problems in individuals for some specific health feature compared to DWS that intend to identify health problems in individuals. We mainly identify three key design requirements for activity trackers that distinguish between digital healthcare services and digital wellness services:
1) DHS require collecting accurate data for medical purposes, e.g. accurate data on heart rate, sleeping patterns, etc. whereas DWS may not require accurate data but rather an estimate, e.g., collecting average heart rate that can help in identifying health problems; 2) DHS may require short-term usage of the tracker with focus on some specific health problem, whereas DWS may require long-term usage to identify health defects in individuals; 3) DHS may have data confidentiality requirements whereas DWS may not have such requirements. In our review, we study research work that focuses on digital wellness services using activity trackers in order to gain an indepth understanding of how literature addresses behavioural change in individuals and the development of wellness routines that are sustainable over time.

The research shows a clear and distinct inadequacy of studies that focus on the age group termed as 'young elderly'. The young elderly age group range from 60-75 years of age and is massively increasing. Literature studies show that mobile wellness services do not adequately address this market segment (Nikou, 2015). Low birth rate in the developed countries has caused increase in aging and it is estimated that by the year 2050, people at the age of 65 and more will be more than 1.5 billion globally (Pop, 2015). The market for this age group is estimated at 80 M in EU (expected to be 97 M by 2020) and 810 M globally (Pop, 2015). It is important that focused efforts are carried out to develop healthy habits and routines in them as with age among the ageing population. An increase in disabilities and chronic illness is observed in the older age (Kang et al., 2008). This will eventually create additional financial and social strain on health budgets and policies. There is, thus, a need for prevention-driven approaches for this age group in order to develop healthy habits and routines among them before they enter the old age group.

The main contributions of this article paper include identification of key design trends in this domain and summarization of different design recommendations according to the design goals. The review also suggests need for aggressive prevention-driven approaches for young-elderly in order to reduce future financial and social burden on societies and governments. We suggest an introduction of action design research in this domain in order to encourage

users to be part of the co-creation process that would facilitate a reduction of adoption barriers for the young elderly.

The paper is organized as follows: Section 2 explains our review methodology. Section 3 explains the result of this research on the basis of the research questions that we have formulated. In section 4, we discuss what we learned from the review and the need for an ADR approach to designing wellness wearables. Section 5 concludes the paper and discusses our future work.

2. Review Methodology

Our primary research objectives in conducting this review are addressed above. In particular, we aim to answer the following research questions:

- What is the current trend of research in designing wearables to create a behavioural change for individuals?
  - The answer to this question will help in analysing the current state of art in this area and help to identify research gaps in it.
- What are the different research approaches currently being employed to develop wearables that create behavioural changes in individuals?
  - The answer to this question will help us understand if the existing research approaches are adequate to create desirable results for individuals or if there is a need to work on research methodologies that can create the required results.

2.1 Sources of Studies

The first step in conducting any literature research in a systematic manner is to exhaustively search different sources for relevant literature. We selected the following search repositories: Web of Science, Google Scholar, Science Direct, Wiley Online Library, ACM Digital library, IEEE Explore and Association for Information Systems Electronic library. We use Google Scholar to ensure that we cover relevant literature that is covered in other databases and in volumes by miscellaneous publishers.

2.2 Search Terms

In the second step, we identify search terms and further narrow our search by defining inclusion and exclusion criteria. The search terms we used are: activity trackers for wellness, wearables, wellness routines, wellness interventions and technical interventions. The search results were narrowed down based on the following inclusion and exclusion criteria:

2.2.1 Inclusion Criteria:

Articles included should fulfil the following criteria: articles published in peer-reviewed venues, articles published in the last 10 years, i.e. 2005 – 2015 and articles must address a certain combination of words, i.e. (activity trackers/ wearables) + (routines/ daily activity / everyday life/ behavior change/ long-term use) + (wellness/ well-being)

2.2.2 Exclusion Criteria:

Articles are filtered out based on the following criteria: articles that address digital healthcare/patient engagements, talk about workplace/community wellness, talk about animal wellness, talk about process of wellness management, e.g., (McComack and Forlizzi, 2000); articles that present design of devices to track physical activity but not on how it addresses wellness and wellbeing etc., e.g., (Popleteev, 2015), that use consumer electronics like remote controls etc. for wellness purposes (Nawyn et al.,2006).

2.2.3 Selection of Primary Studies

We identified 210 studies from different repositories using search terms. Based on the selection criteria, we reviewed titles and abstracts of the articles and identified 67 studies. We read the contents of the articles after downloading them. In parallel, we created an excel sheet to record details of each paper, for example, author, year, wearables used, age group, aims of study, etc. We added relevant references from the studied articles using snowballing (Jalali and Wohlin, 2012). The article selection was refined again by applying our selection criteria and removing redundant articles. The final selection of primary studies included 22 articles.

3. Results

Recent advancement in wearable technology has resulted in a great influx of different types of wearable activity trackers in the market that may or may not serve different purposes. In addition, there is a considerable amount of work produced by the research community in recent years that give different design suggestions, research prototypes and design strategies to build wearable activity trackers that can produce behaviour change in individuals. Studying the work done in designing such wearable activity trackers is thus important in order to get a better picture of the varying types of information provided by experts.
We thus reviewed the primary research articles in detail to infer find answers to our research questions. The summary of the research results is shown in Table 1 (ordered by year).

Table 1: Reviewed Studies and their Characteristics
(Here, N/A = Not Applicable, Recomm. = Recommendations, App. = Application)

Papers	Research Aim	Routines Studied	Method Used	Sample Size	Age Group	Wearable brand/ technology Studied	Duration of Use
(Jafarinaimi et al., 2005)	New App./ Evaluation	No	User Study	1	55	Breakaway	2 weeks
(Consolvo et al., 2006)	New App./ Recomm. / Evaluation	No	Interviews	13 Female	28-40	Pedometer + Mobile S/W	3 weeks
(Lin et al., 2006)	New App./ Evaluation	Yes	User Study	19	23-63	Fish'n'steps	14 weeks
(Toscos et al., 2008)	New App./ Evaluation	No	User Study	8 (girls)	13	Pedometer + Mobile	3 weeks
(Consolvo et al., 2009)	New App./ Evaluation	Yes	User Study	28	25-54	UbiFit	3 months
(McMurdo et al., 2010)	Evaluation	Yes	User Study	204	> 70	Pedometer	6 months
(Klasnja et al., 2011)	Evaluation	Yes	Lit. Review	N/A	N/A	N/A	N/A
(Ananthanarayan and Siek, 2012)	Recomm.	Yes	Lit. Review	N/A	N/A	N/A	N/A
(Vankipuram et al., 2012)	New App./ Evaluation	No	User study	4+4	25-35, 69-75	Accelerometer mobile S/W	1 week each
(Fausset et al., 2013)	Recomm./ Evaluation	No	User Study	8	60-69	Striiv, Fitbit®, FuelBand Nike+	2 weeks
(Fritz et al., 2014)	Recomm.	Yes	Interviews	30	20 – 60	Fitbit, pedometer, etc.	3-54 months

(Harrison et al., 2014)	Evaluation	Yes	User Study, Interviews	50	Not Mentioned	Fitbit	16 weeks
(Ryokai et al., 2015)	New App.	Yes	User Study	5	25-38	HealthViz, Lumo	1 week
(Amor and James, 2015)	Recomm.	No	Case Studies	N/A	N/A	N/A	N/A
(Patel and O'Kane, 2015)	Recomm.	Yes	User Study	11	21-35	Fuelband4, Samsung Gear, Fitbit3, etc.	4 weeks
(Lazar et al., 2015)	Recomm./ Evaluation	No	Interviews	17	18-59	Various	2 months
(Gouveia et al., 2015a)	New App. / Evaluation	Yes	User Study	256	open study	Habito	10 months
(Shih et al., 2015)	Evaluation	Yes	User Study	26	20-24	Fitbit	6 weeks
(Schmidt et al., 2015)	New App.	No	Product Design	N/A	N/A	Digital Fitness Coach	N/A
(Harrison et al., 2015)	Recomm.	Yes	Interview, Survey	24	18-55	Fitbit, Misfit, Moves, etc.	1 hour 20 mins
(Meyer et al., 2015)	Recomm./ Evaluation	Yes	User Study	12	25-70	Fitbit Ultra , fitbit flex, etc.	2 weeks
(Preusse et al., 2016)	Recomm./ Evaluation	No	User Study	1	65-75	Fitbit One fitbit flex, etc.	28 days

3.1 RQ 1: What is the current trend of research in designing wearables to create behavioural change in individuals?

Research in the area of wearable activity trackers is still in its early phase of development and recent years have seen a sudden increase in research works that investigates how wearable activity trackers can create behaviour changes and encourage the building of routines. There is thus a plethora of information and suggestions on how to design wearable activity trackers that will have a behavioural impact.

We found the following key trends in research studies on the design of activity trackers for behaviour change.

i. Novel Mobile Applications using Wearable Activity Trackers
ii. Design Recommendations for Wearable Activity Trackers
iii. The evaluation of Wearable Activity Trackers

These trends are not mutually exclusive and are explained in the following sub-sections.

3.1.1 Novel Mobile Applications using Wearable Activity Trackers

Several studies use typical sensors like pedometers and accelerometers as wearables as shown in Table 1 and build novel mobile applications on top of them using different design strategies to create a behavioural impact on individuals. Pedometers generally count steps i.e., the frequency of activity, whereas accelerometers capture the intensity of dynamic movement of the individual.

Consolvo et al. (Consolvo et al., 2006) developed a mobile software, *Houston*, which used data from pedometers to investigate the use of technology to encourage women to increase their physical activity. Lin et al. (Lin et al., 2006) created a social computer game, in order to motivate individuals at work to stay physically active. In the game, a virtual fish tank was displayed at a central place at work and each fish represented each individual. In designing the game, authors used pedometers to measure a daily step count of the users and used this data to describe the moods of the fish. The more active an individual was, the happier and bigger his fish was. Toscos et al. (Toscos et al.,2008) conducted a user study with young girls using pedometers and a mobile application to study the effect of social support groups to increase their physical activity. Vankipuram et al. (Vankipuram et al., 2012) and Gouveia et al. (Gouveia et al., 2015a) used accelerometers. The work of Vankipuram et al. used data from accelerometers and provided real time data to users of a mobile application to enforce positive behaviour among older adults. Gouveia et al. (Gouveia et al., 2015a) designed a new mobile application *Habito* that used the data from accelerometers. The purpose of developing this application was to gain more control and access over users' activity data that was not possible with commercial activity trackers. In some other work, Consolvo et al. (Consolvo et al., 2008), (Consolvo et al., 2009) built a new mobile application UbiFit Garden using data from a fitness device, Mobile Sensing Platform (MSP). The application used screen background of mobile phones to display a garden that blooms as the physical activity of the individual increases.

Table 1 shows that some studies have also used commercial devices to build novel applications on top of them. Ryokai et al. (Ryokai et al., 2015) built a mobile application that aims to provide better visualization of data gathered from different wearables in order to improve communication between users and their health coaches. Schmidt et al. (Schmidt et al., 2015) proposed the design of a personal fitness coach using data from different wearable devices.

3.1.2 Design Recommendation for Wearable Activity Trackers

Table 2: Design Recommendations for Wearable Activity Trackers

Age Group	(Toscos et al., 2008), (Vankipuram et al., 2012), (Fausset et al., 2013), (Preusse et al., 2016)
Social Interaction	(Lin et al., 2006), (Toscos et al., 2008) and (Consolvo et al., 2009)
Encouraging Adoption	Consolvo et al.(Consolvo et al., 2009)
Encouraging Long-term use:	(Fausset et al., 2013), (Gouveia et al., 2015a)(Meyer et al., 2015), (Harrison et al., 2015) (Gouveia et al., 2015a)
Context of Use	(Gouveia et al., 2015a), (Patel and O'Kane, 2015)
Deployment Strategies	(Preusse et al., 2016)

In this section, we categorize and summarize different types of design recommendations. Design recommendations are applied to new products and services and are proposed with a certain context or design goal in mind. In literature, we found several design recommendations and strategies for designing wearable activity trackers for different purposes. Some researchers also discuss barriers to adopting existing wearable activity trackers. In Table 2, we present a list of research articles that present design recommendations and categorize them according to the different design goals they address.

- **Age Group:** Some studies provide design recommendations/strategies for specific age groups. In this category, we found design recommendations for young girls (Toscos et al., 2008) or older adults (Vankipuram et al., 2012), (Fausset et al., 2013), (Preusse et al., 2016).

- **Social Interaction:** Researchers have also adopted social interaction as an effective design strategy in encouraging individuals to be more physically active. The work of Lin et al (Lin et al., 2006), Toscos et al. (Toscos et al., 2008) and Consolvo et al. (Consolvo et al., 2009) address this behaviour intervention.
- **Encouraging Adoption:** Technological interventions can encourage physical activities in individuals (Consolvo et al.,2006). However, in order to encourage users to integrate wearables in their routines, barriers like short battery life, inaccuracy of measurement of different activities and difficulties in using the device should be overcome (Vankipuram et al., 2012). Overcoming these barriers sometimes comes as a trade-off among these factors, e.g. between ease of use and accuracy of measurement in case of multiple sensors. Lazar et al. (Lazar et al., 2015) studied why users use and stop using smart devices and recommend that wearable devices should be non-obstructive and should not require maintenance in order to encourage users to adopt them in their daily lives. The work of Amor et al. (Amor and James, 2015) reviews two case studies and suggests obtrusive designs along with size and weight of devices that can prevent users from adopting wearable technology. The battery life and sensing capability interoperability also pose challenges to the future of this technology. Personal preferences can also affect the adoption of activity trackers according to studies by Shih et al. (Shih et al.,2015).
- **Encouraging Long-term use:** Some researchers aim to design wearable activity trackers that result in long-term adoption of the device. The work of Harrison et al. (Harrison et al., 2015) and Gouevia et al. (Gouveia et al., 2015a) discuss the barriers and strategies to engage users with wearable activity trackers for longer use.
- **Context of Use:** The context of use of the device, like location of the device in use, when designing wearables for wellness is also important (Gouveia et al., 2015a). Patel et al. (Patel and O'Kane, 2015) also emphasizes the importance of the context of use and suggests appropriate design recommendations for use of wearables in the gym.
- **Deployment Strategies:** In spite of all the design recommendations and strategies to encourage users to adopt wearables and motivate them to use them in their everyday life, the deployment strategies of these devices also play a significant role in encouraging users to adopt them. Preusse (Preusse et al., 2016) suggests deployment strategies for wearable activity trackers like creating tutorial videos that facilitate the learning of new/ difficult features, allowing trial-of-use periods etc.

3.1.3 Evaluation of Wearable Activity Trackers

In order to evaluate how effectively a device meets its design goals, different evaluation methods are used. Almost all the studies that developed novel approaches and prototypes for creating behaviour changes individuals' for wellness, conducted user studies to evaluate the effectiveness of the approach. Also, the studies that did not present novel approaches or prototypes, conducted user studies with commercial trackers to identify barriers in usage and to give design recommendation for new devices.

- **User Groups:** The selection of users groups to conduct user studies is guided by the design goals. These design goals drive the selection of users based on the following characteristics:
    - **Age:** Works that target older adults, select user groups accordingly (Preusse et al., 2016), (Fausset et al., 2013), (McMurdo et al., 2010) and those targeting teens (Toscos et al., 2008), select the user base accordingly. Most of the studies do not target a specific age group and select the user base from a wide age range.
    - **Sample Size:** The sample size in the selected studies range from 5 to 50 with exception of two studies (Gouveia et al., 2015a), (McMurdo et al., 2010).

Gouveia et al. (Gouveia et al., 2015a) presents a study with 256 users of an activity tracker to study how users engage with activity trackers and how this engagement affects their physical activity. The work of McMurdo et al. (McMurdo et al., 2010) studied 179 older women in order to determine how behavioural and technological interventions effect their physical activity.

  - **Types of users:** The users selected for most of the studies are mostly motivated individuals who are interested in improving their wellness and physical activity e.g., (Meyer et al., 2015), (Consolvo et al., 2008),(Consolvo et al., 2009) etc. Similarly, most of the users have technological background with familiarity to either computers or activity trackers e.g., (Fausset et al., 2013), (Fritz et al., 2014), (Ryokai et al., 2015). Gouveia et al. (Gouveia et al., 2015a) uses an in-the-wild study to get an unbiased estimate of adoption from people with different levels of 'readiness'

- **Use of wearable technologies/ devices:** Three studies used pedometers, two studies used accelerometer, one study used MSP and eleven studies used commercial wearable activity trackers to explore and study design aspects of wearable activity trackers. The studies that used wearable activity trackers like 'pedometers', 'accelerometers' and 'MSP' built their own mobile applications using the data from trackers. This is because, unlike commercial devices and their applications, building their own applications using data from activity trackers allows researchers to explore different design ideas. It also gives more control and access over users' data and their feedback giving deeper insight for researchers on the how activity trackers are being used. On the other hand, commercial devices are generally used to study users' adoption barriers and to investigate how to overcome such barriers and additionally to propose design strategies and recommendations to improve them.

3.2 RQ 2: What are the different research approaches currently being employed to develop wearables that create behavioural changes in individuals?

Our review of the current research studies shows that most of the approaches follow a design research approach. Design research (DR) methodology is an analytics approach to research in Information System (IS) design and implementation. It require the creation of a novel artefact (to be applied) for a particular problem domain and an evaluation to ensure that it is useful for that specific problem (Henver et al., 2004). The design research paradigm treats design as a strategy for developing and refining theories. It includes analysing the usage and performance of the designed artefacts.

As shown in Table 1, the studies included in this review either involve literature reviews of previous studies, interviews or the conduct of user studies to evaluate novel applications and approaches on using wearables for wellness intervention, hence adopting a design research methodology. The results of these studies either provide design recommendations that can be applied to new devices, or be used to remove barriers for an adoption of existing devices.

4. Discussion

In analyzing the existing literature and answering the research questions, we discovered interesting insights and research gaps as outlined below.

4.1 Wellness Wearables for Young Elderly

In answering RQ1, i.e. to understand the current trend of designing wearables, one of our attributes of study was the age group for which they are designed. Table 1 shows that wellness wearables are studied for varying age groups. While studies are conducted with

older adults, most researchers working with the elderly population define this age group differently. Some researchers have worked with the older population including the age range that we define as young-elderly, but define it as older adults with varying age ranges.

Older adults are studied to investigate their acceptance and adoption barriers for activity trackers (Preusse et al., 2016), (Fausset et al., 2013) or to study how the use of behaviour change intervention affects the physical activity of older women. Varying age groups are studied under the bracket of older adults >70 (McMurdo et al., 2010), 60-69 (Fausset et al., 2013), 65-75 (Preusse et al., 2016), 69-75 (Vankipuram et al., 2012). All these studies show barriers that hinder older adults to accept and adopt wearable activity trackers. Some researchers are working with bigger samples with wider age ranges e.g., (Lin et al., 2006) works with the age group of 23-63, (Vankipuram et al., 2012) works with 23-35 and 69-75, (Fritz et al., 2014) select users with age range 20 – 60, etc. Working with a wider age range reduces the possibility to enhance the user behaviour towards wellness related activities. The most important thing missing in this literature is the definition of elderly and it varies in the perspective of every researcher. We have realized this gap and formed the concept young elderly that is age group 60-75 years.

4.2 Sustainable Wellness Routines with Wearables

Routines can be created for individuals using wearables as behavioural interventions to improve wellness. In investigating RQ 1, we studied how existing research addressed the creation of wellness routines in individuals. Table 1 shows that creating wellness routines with wearables is an active area of research with a number of researchers providing design recommendations and evaluation studies for creating wellness routines e.g., (Gouveia et al., 2015a), (Shih et al., 2015) and highlighting the need for sustainable wellness routines for individuals (Ananthanarayan and Siek, 2012).

However, creating routines that are sustained even after an individual stops using the wearable is a challenge as users go back to their old unhealthy habits once the intervention is withdrawn (McMurdo et al., 2010. This implies that additional support could be needed to sustain the behavioural changes. While wearable activity trackers for short-term usage have their own potential market and usage, e.g. digital healthcare, a long-term usage of wearable activity trackers may offer much needed behavioural intervention in a continuous non-interrupting manner that can increase wellness of individuals. Designing wearable activity trackers for long-term usage requires different design strategies than those designed for short-term usage (Ananthanarayan and Siek, 2012). Creating sustainable behavioural changes for individuals is an interesting design challenge, especially, while addressing the needs of young elderly; working with young elderly, researchers have shown that 60+ citizens do not change their routines or adopt wellness services without a good reason (Carlsson and Walden, 2015).

4.3 Action Design Research

In section 3.2, we have found that researchers have increasingly adopted design research methodology to create digital wellness interventions with wearables. However, design research, i.e., creating innovative services and applications for a problem domain and then evaluating the users to study their effectiveness, did not always build sustainable wellness routines (McMurdo et al., 2010). This requires a rethinking of research methodologies to design digital wellness interventions that would involve users of the services in a co-creation process rather than just the customization of services according to user needs. “Co-creation refers to allowing the customer to co-construct the service experience to suit his/her context (Prahalad and Ramaswamy, 2004). Involving the ‘young-elderly’ in the service creation process can lower the barriers for adoption of wearable activity trackers for sustained use.

We thus encourage an adoption of action design research (ADR) methodology to create digital wellness services using wearable activity trackers. According to Sein et al. (Sein et al., 2011) the ADR is built on four stages i.e., a) Problem formulation; b) Building, Intervention and evaluation; c) Reflection and learning; and d) Formalization of learning. These four stages are built upon seven principles; i) Practice-inspired research, ii) Theory-ingrained artefact, iii) Reciprocal shaping, iv) Mutually influential roles, v) Authentic and concurrent evaluation, vi) Guided emergence and vii) Generalized outcomes.

With the ADR approach, users can intervene and evaluate the design and building of the artefact simultaneously. This facilitates dealing with the complexity of the problems that involve co-creation. ADR moves towards general solutions by creating and evaluating artefacts that can address classes of problems than can be characterized from the context and the user experiences and their feedbacks.

5. Conclusion and Future Work

The use of wearable activity trackers has become a growing trend among young and old. This is mainly motivated by initial curiosity and a desire to look and feel updated about the latest technologies. Recent years have seen a sudden rise in the number of wearable activity trackers that are available commercially and that may or may not serve the same purpose. Research efforts have also increased manifold in recent years to design wearable activity trackers that can motivate individuals to engage in healthy physical activities in their everyday life. In this work, we carried out a systematic literature review to study research work done in this area in order to understand the state of the art and to identify potential areas of future work.

The main motivation for our work is to find out how the existing literature addresses the creation of wellness routines with wearables, especially for 'young-elderly'. The young-elderly age group is increasing worldwide and there is a need for efforts to help in creating sustainable wellness routines for them in order to reduce a future financial and social burden on the society.

Our work focuses on physical wellness of individuals and does not cater to other dimensions of wellness like mental, occupational, spiritual etc. Though all effort has been made to conduct the review in a systematic and thorough manner, there might be some studies that did not appear in search repositories and might have been missed. However, best efforts have been employed to include research articles that fit the inclusion criteria of our review. Wearable activity trackers are designed with different design goals in mind and hence should be designed with specific requirements in mind. A 'one-size-fits-all' approach does not provide constructive results since every target group and use has its own set of requirements. Similarly, the 'young-elderly' age group has long been ignored. The research efforts that work on designing wearables for older adults do not appear consistent in their definition of older adults or they are larger age ranges, which will reduce their effectiveness. The review further suggests a need for new research approaches in this domain in order to involve 'young-elderly' in a co-creation process of wellness services to reduce the adoption barriers for wearable activity trackers.

Learning from our lessons in this review, in the future, we are interested in adopting an ADR approach to involve young-elderly in co-creation processes to design wearable activity trackers that could support sustainable wellness routines. We are working on planning and conducting user studies with groups of young-elderly such that they all would carry out the same exercise with the condition that half of the group would use activity bracelets and the other half would use just smartphones to record their activities. We work on this study with an assumption that people using wearable activity trackers stay fit for a longer time with

better sustainability of wellness interventions. In addition, we are interested in observing and collecting information from users who are involved in creating and evaluating digital wellness services.

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